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About Trying Experiments

THE HISTORY OF the world, like the story of individuals, is the record of experiments. At times, beneficial advances were made; at others, as is usual in experimentation, rather ghastly mistakes were the outcome. But without experiment there would have been no advance at all from the first-man stage of human development.

Experimentation is not so widely written about as are imagination, analysis and creativity.

What do these words mean? You imagine a thing when you see it in your mind's eye; you analyse a thing when you take it apart to see of what it is made; you invent a thing when you put together bits and pieces according to lessons learned in your analysis so as to come close to what you imagined. Experimentation is to try a thing out to see if it will work.

Truth about any phenomenon, from the cause of a common cold to the reason for a slump on the stock market, can be established only by experimental means. Men of science and business learn every day from experiments. By trying things out they constantly correct their ideas, revise their theories, improve their methods, and so come nearer and nearer to what is best.

We may go farther. Experimentation is more than a means to verify the results of inventive processes. An experiment can be the stone cast into the pool deliberately to start ripples.

Speculation versus experiment

Contrast the idea of windy speculation with the idea of finding out by experimentation. In the first, we exhaust our ideas in talk; in the second we assemble our ideas and put them to work. Using our knowledge of things as they are, we apply thought to their improvement.

Claude Bernard, whose book *An Introduction to the Study of Experimental Medicine* has been in print for nearly a century and is still a text-book, found more dominating facts about medicine in twenty years than all the other physiologists in the world.

The essence of Bernard's belief is this: by simply noting facts or piling up observations, we shall be none the wiser. We must reason about what we have observed, compare the facts, judge them by other facts used as controls, and put the outcome to the test by experiment. That is the only way to obtain proof of one's beliefs.

Nothing is easier than to design on paper and put together a contraption made up of wheels, magnets, ratchets and pulleys, but only turning on the power will prove whether it will work and accomplish what is wanted of it.

What one needs is to have an idea, put forward a hypothesis, and then test it.

In practical work in office, factory or the multitudinous facets of everyday living, we may trace our development of something new in this way: we sense a problem and develop a desire to solve it; we gather accurate facts; we mull over our data, incubating an idea; we reach the moment of illumination, when a possible solution comes to us; we test the proposed solution.

Scope of experimentation

Experimentation is not confined to development of glamorous new gadgets, or the uncovering of laws in physics and chemistry. It may be applied effectively in business, for example to reduce waste.

Suppose a business man to say to himself: any work that does not add value to material, does not plan or calculate, does not give or receive essential information, is reducible waste.

He will observe, collect facts, analyse and write down what he finds. He will choose a possibly rewarding spot at which to start, and prepare a hypothesis about what would happen if he did so and so. Then he will try out his plan, testing every step.

In any job, a person can show himself conscious of methods improvement by asking repeatedly: "How can I do the job more quickly or more easily?" If top management is alert to the possibility of advancement it will give supervisors freedom to fail, provided the experiment shows promise of betterment.

Here are some points by which to check the probable value of a change: will it increase production, improve quality, add safety, prevent waste, provide better working conditions, reduce cost or eliminate unnecessary work? The tests given the new system or machine will show whether it is sound, workable and practicable, and whether it has advantages which outweigh its disadvantages.

There is yet another factor to be considered: the human element. Before embarking upon an experiment involving human beings — as in rearranging a factory, redistributing work in an office, or introducing new methods — write down the possible effect the change will have in the life of everyone concerned with it. Take into account the probable reactions, good and bad. You may find that the success of the experiment technically would be the ruin of more valuable things.

Challenge the obvious

Any person of spirit will find it thrilling to challenge the obvious, to question the accepted way of doing things, and to experiment with new ways. You have a "hunch"; you think up alternatives; you dream up ways and devices by which to test your guesses — as Leonardo da Vinci did when he pierced a small hole in a window blind and saw an image of the outside world reproduced in miniature on the wall of his room, thus foreshadowing photography.

Great music is the final result of inspiration followed by rewriting and trying again. Great art is preserved to us because men made experiments with drying oils. Poets reached immortality by experimenting with verse form. The columns raised by the Greeks, and still acknowledged as perfect architectural examples, were the result of experiment which widened them in the centre to eliminate the illusion of narrowness.

Experiment is not confined to universities and industrial laboratories. Every person in Canada can be a research worker, experimenting so as to find better ways of doing things. Robert P. Crawford remarked in *The Techniques of Creative Thinking:* "The tragedy of life is not lack of brain power or education but doing so little with what we have."

The incandescent lamp was not the invention of a lampmaker, but of a former telegraph worker who continued his experiments even after the learned men of his time quoted two fundamental laws of physics to prove that he couldn't succeed. The first ground handful of nitre, sulphur and charcoal drove a monk's pestle through the ceiling — Roger Bacon had found gunpowder. His motto was: "Take nothing for granted; use your own eyes and test all new theories with your own hands."

How to start

One way to start is by prodding your imagination. Sit down with a pencil and a blank sheet of paper and think of experiments you can make: candle-wax instead of "elbow grease" on that so-hard-to-raise window; a loose-leaf book of numbered form letters so that you answer routine mail by writing a figure in the corner, a figure which your secretary translates into a letter ready for your signature; a jig that will eliminate time-consuming measurements on the production line. Pencils, set in motion by imagination, can act as crowbars in moving our minds.

Note the classic simplicity of this formula. You become aware that there is something that may be done, some problem to solve, some improvement to be made. You make a proposal to yourself of some solution; you clarify the problem and the solution as far as you can; you decide upon a plan of action; you try out your plan.

In the ordinary course of life you will not wish to try an experiment until you feel the need for a change. Nevertheless, there are occasions when it is advantageous to experiment for the sake of experiment. This is so for two reasons: you may find that a change in detail or form or method or location will improve what you have accepted as being satisfactory; and you will benefit by the mental shaking up that experimentation gives you.

You take a walk, as it were, on the borders of your business, and pursue what happens to present itself to your attention. Ideas may show themselves when you are looking for them, but they are just as likely to be seen out of the corner of your eye when you are looking at something else.

This is where the widely-read or widely-experienced person has the advantage over those with less broad knowledge: he has a background of material to which to relate new thoughts.

This background comes from observation, but we must guard against the fallacy of thinking that to observe is enough. An observer gathers data as nature and environment offer them; an experimenter applies investigation so as to vary the outcome or to make something new of it.

Nevertheless, observation is a vital step in experimentation. Dr. Alexander Fleming set aside a culture of

bacteria one day, and observed when he examined it hours later that it was spoiled. The culture grew on only half the plate; the other half was spotted with a blue-green mold. He wrote in his note-book: "I was sufficiently interested in the anti-bacterial substance produced by the mold to pursue the subject," and so he discovered penicillen.

Get the facts straight

In planning and carrying out an experiment of any sort you must never lose sight of the facts. From the first tentative step toward an objective until the final test of validity, experimentation deals with facts. If a fact be ignored or if it be erroneous the whole structure will crumble.

The quantity of facts needed will vary. Edward Hodnett illustrates this neatly in *The Art of Problem Solving* where he says that if you were buying rope for a clothes-line you might be content to examine ten samples, but if you were buying rope for parachutes you would likely wish to test hundreds of pieces to judge their strength.

The minute precision of the facts needed will also differ. If you are experimenting with concrete it is enough to know that one part cement, two parts sand and three parts gravel will provide concrete with such and such qualities. If you are working with bacteria you will need to collect your facts with an instrument like that used in the Institute of Biology at the University of Montreal: it can measure to a one-hundred-thousandth of a degree of temperature.

Facts are neither great nor small in themselves, but relatively so. The proportions of concrete are just as important in the foundation of a building as is the temperature of bacteria in the research laboratory.

Having collected the facts with which to start experimenting, we must clarify them, throw them into some sort of order, and isolate the essentials. The logic of experiment consists in the weighing of probabilities, discarding details judged to be irrelevant, ascertaining the general rules that govern cause and effect in what we are doing, and trying out our hypothesis by controlled tests.

What is a hypothesis? It can be thought of as an informed guess. We use the knowledge we already have to make a preliminary conjecture about what will happen if we take another step.

Even when an experiment shows our hypothesis to be mistaken, we have gained something. The alchemists founded chemistry by pursuing theories that turned out to be false. Modern scientists, says Dr. Hans Selye, look upon any hypothesis as expendable: it is a launching platform for testing ideas. He summed it up in this way in an article in *Maclean's* magazine in mid-August: "No count has ever been made, but it is quite certain that for every series of experiments that ends in a 'useful' result like insulin, some thousands of series are completed that are apparently useless."

Your fruitless experiment has not been useless. It has eliminated one possible way of doing something, reducing the confusion of choices: and truth is more easily evolved from error than from confusion.

Nevertheless, the man who embarks upon something new must school himself to face unpleasant facts: the fact that a cherished idea turns out to be unsound, that the wrong road has been taken and must be retraced. He must be skeptical, questioning his results rigorously if he is to be certain, at the end, that he has a true solution and the best product.

Keeping records

What are the sins marked in red in the experimenter's rule book? To be dishonest or careless in setting up the elements of the experiment; to be neglectful in keeping a record of everything done; to fail to take into account every small part of the ingredients and every action of the apparatus. Without records, successes cannot be repeated and failures have taught no lesson.

There is a bonus value in keeping complete records: the mere act of putting down on paper the what, where, when, why and how of any piece of work will, of itself, generate ideas of how the work can be done in an improved manner.

Notes help us to avoid the fallacy of attributing effects to wrong causes. They enable us to see that not everything that follows something is caused by it. They give us the data from which to find whether there is a third influence, not taken into account in our experiment, which is influencing the result.

Trying new ways

There are several lines to follow in trying to improve a product, a service or a system.

Originality may be, but is not always, a matter of impulse or intuition. Most of us can find it if we seek it diligently, and no one can ever become a genius except by stepping out, by experimenting. Intuition solves only problems about which we already know a lot.

One way to hasten the development of something new is to experiment with our material in various combinations. The composer of music works with combinations of notes, moving them around on the scale into pleasing harmonies, trying them out on the keyboard of his piano; the inventor works with combinations of substances and mechanisms; the office manager works with combinations of people and

records and machines, tuning up his organization by trying this and that change of duty or partnership of workers.

Another way is by variation, by putting the shoe on the other foot. We ask ourselves what would happen if we placed the files in the centre of the office instead of along the wall; if we curved this assembly line instead of having it straight; if we changed the colour of the package in which we sell our goods. We can vary things so as to make them bigger or smaller, heavier or lighter, thicker or thinner. In its new form the article may serve its purpose more efficiently or more cheaply, or it may adapt itself to an altogether different purpose.

Experiment of this sort is, in its way, deliberate creativeness. It demands that we have expectant, supple and receptive minds; that we set goals and get going toward them. The experimental mind, which is a mind that retains its youth, has a tendency to move of itself instead of waiting at the dock for a tug.

Ballast exists everywhere: all the pebbles of the harbour, all the sand on the beach will serve for it; but men to steer the ship on a voyage of exploration are rare. The ability to originate is typical of the executive-minded man. A clerk keeps records; the executive grounds himself on the clerk's collected facts; he goes on to imagine new combinations of facts, and he experiments in search of new results. He sails into new territory.

Initiative

Experiment quite often entails nothing more or less than initiative — "Let's try it now". The inner driving force of imagination and conception should not be kept waiting for a more favourable time or for a flash of inspiration. That is how great ideas are lost.

The way to progress is by cultivating qualities of venturesomeness. A person may score 100 per cent in a written examination and yet make nothing of his life because he fears to apply what knowledge he has in an experimental way.

Initiative requires the courage to face the consequences of trying new things. Horatio Hornblower says in one of C. S. Forester's stories: "I'd rather be in trouble for having done something than for not having done anything." In its highest form this courage displays itself in personal experiment by medical research workers: like the German doctor who inoculated himself with a fungus he suspected of causing ringworm; the British doctor who gave himself malaria to prove that a mosquito, not climate, spreads the disease; and the Scottish doctor, James Young Simpson, sniffing chloroform to test its effect as an anaesthetic.

Another quality needed is persistence, or stick-to-it-iveness. One may have the desire and the ability to create, to change beneficially, but there are difficulties galore in doing any new thing. Experimentation is not a slot machine into which you slip a coin and get the answer on a printed card.

There would never have been an improvement of any kind at any time if the person with a new idea had been stopped by the first "It can't be done" or "It won't work."

To experiment you must determine to work creatively despite frustrations, rebuffs and failures. You have to challenge sacred cows. To experiment is to get lost and err, but nonetheless to acquire knowledge. You have to learn to fail intelligently, making use of errors to find certainty. After failing in 700 experiments Edison said: "Now we know 700 things that won't work". The one time we must not fail is the last time we try.

Second-hand materials

The person with an urge to improve things is often like the person arriving late at a department store sale: he has to take goods which others have seen and not taken. Leonardo da Vinci wrote in his note-book: "the men who have come before me have taken for their own all useful and necessary themes." Picking up their leavings, he experimented with the elements, mechanics, flying machines, art, tanks, explosives, and a machine to sharpen 40,000 needles per hour, probably the first mass-production machine in history.

Time and again throughout the advance of science and commerce the consequence of following up or not following up the work of others has been very great. Originality does not consist merely in thinking of some basic principle first, but in seeing some opportunity to apply it at a point in time when it can be pursued with profit.

We should not hesitate to start from where other people left off. Ideas grow and pass from mind to mind. The engineering and technology of the present are the accumulated heritage of the past, the combined experiments of hundreds of generations. George Stephenson put this with clarity and modesty when he said, at the height of his fame: "the steam locomotive was not the invention of any one man, but of a nation of mechanical engineers."

The experimenter will never rely upon chance. "Chance" is a word we invented to express the known effect of unknown causes. He will persist in his endeavour to bring about desired effects by manipulation of means. He will reach for the stars, and though he may not get one he will enjoy trying.

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